Thoracic kyphosis and ventilatory dysfunction in unselected older persons: an epidemiological study in Dicomano, Italy.

Thoracic Kyphosis and Ventilatory Dysfunction in Unselected Older Persons: An Epidemiological Study in Dicomano, Italy

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OBJECTIVES: To assess whether kyphosis is associated with ventilatory dysfunction in older community dwellers.

DESIGN: Cross-sectional study.

SETTING: The unselected population of Dicomano, Italy aged ≥ 65 years.

PARTICIPANTS: A total of 323 nonheart failure participants underwent clinical evaluation for the presence of kyphosis and spirometry. The severity of kyphosis was estimated from the difference between standing stature and knee-height-derived stature and from the occiput-wall distance.

MEASUREMENTS: Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), and prevalence of obstructive and restrictive ventilatory pattern.

RESULTS: The 130 kyphotic participants (40.2%) had an adjusted 2.5 prevalence odds ratio (POR) for dyspnea (95% confidence interval (CI) = 1.1–5.8). FVC% and FEV1% were lower in the presence of kyphosis ($P < .01$); their deficit was proportional to kyphosis severity. The ventilatory dysfunction was underestimated when reference spirometric parameters were calculated based on standing stature, compared with knee-height derived stature. Of the kyphotic participants, 56.2%, 26.9%, and 16.9% had spirometric normal, obstructive, and restrictive patterns, respectively. Kyphosis was associated with a restrictive (adjusted POR = 2.3, 95% CI = 1.1–4.8; $P = .021$) and an obstructive ventilatory pattern (adjusted POR = 3.3, 95% CI = 1.7–6.5; $P < .001$).

CONCLUSION: In unselected older persons, kyphosis is associated with dyspnea and ventilatory dysfunction of a restrictive and an obstructive type. Kyphosis should be included in the differential diagnosis of dyspnea and ventilatory dysfunction in the elderly. **J Am Geriatr Soc 52:909–915, 2004.**

Key words: kyphosis; elderly; lung function; dyspnea; epidemiology

The prevalence of thoracic kyphosis increases with advancing age[1,2] as a combined effect of osteoporotic vertebral fractures,[3] arthritis,[4] intervertebral disk thinning, and reduced muscular tone.[5] Thoracic kyphosis has been associated with height loss and thoracic vertebral fractures,[6] and longitudinal epidemiological studies have demonstrated that prevalent spine deformities predict relevant clinical outcomes, such as hospitalization and mortality.[7] In particular, some authors have reported an increased risk of pulmonary death (pneumonia and chronic obstructive pulmonary disease exacerbation) associated with low bone mineral density, vertebral fractures, and spine deformities.[8,9]

In spite of the aging-associated prevalence of thoracic kyphosis and of the well-known effects that severe spine deformities have on lung function in younger individuals, the ventilatory effects of thoracic kyphosis in the elderly have been poorly investigated, at least in unselected older persons. In 74 women referred for evaluation of osteoporosis, a modest decline in vital capacity was first reported as a function of the number of thoracic wedge fractures.[10] These results were replicated in a study of 34 men and women with spine osteoporotic fractures, compared with 51 patients with nonosteoporotic chronic low-back pain.[11] Because both these studies enrolled a small number of highly selected individuals, the clinical implications of these findings remained unclear.

The current study was conducted to verify the hypothesis that thoracic kyphosis can cause ventilatory dysfunction and dyspnea in unselected older persons. Furthermore, because height enters in the equations predicting reference values of spirometric variables, the effect of height underestimation secondary to kyphosis on the spirometric assessment of ventilatory function in the elderly was also evaluated.

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METHODS

Study Population and Protocol

This study was part of an epidemiological survey on heart failure in the elderly that was conducted in Dicomano (Insufficienza Cardiaca negli Anziani Residenti a Dicomano, ICARe Dicomano study,[12]), a small rural town near Florence, Italy. The ICARe Dicomano study is consistent with the principles of the Declaration of Helsinki on the conduct of clinical research involving human subjects. Formal institutional review board approval for this study was not needed at the time of the study in Italy.

The entire unselected, home-dwelling, elderly (aged $\geq$65) population recorded in the city registry office was enrolled, with the exclusion only of persons living in a nursing home. After informed consent was obtained, multidimensional geriatric assessment data were collected using home interview, laboratory testing, and clinical and cardiopulmonary instrumental examination. As of April 25, 1995, 864 residents in Dicomano aged 65 and older were initially eligible for the ICARe Dicomano survey, and 614 (71.1%) underwent full examination. Reasons for nonparticipation were death or institutionalization before data collection in 21 cases and refusal in 229.

Data Collection

Participants underwent complete clinical examination, 12-lead ECG echocardiography, and spirometry. During the clinical examination, a standardized ascertainment of comorbidities was performed based on questionnaires, physical examination, laboratory tests, and instrumental data.[12] Pertinent anthropometric data, such as body height (cm), body weight (kg), occiput-wall distance (OWD, cm), and knee height (cm), were also collected. Physicians who were unaware of anthropometric and spirometric data recorded the presence of kyphosis, clinically evident as an exaggerated posterior convexity of the thoracic spine.

Before spirometry, functional status was assessed using Goldman's specific activity scale,[13] which explores tolerance to exertion in standardized daily activities. Four classes can be identified with this scale, corresponding to symptoms occurring at different levels of exertion (Class I: $>$7 metabolic equivalents (mets), Class II: 5–7 mets, Class III: 2–5 mets, Class IV: $\leq$2 mets or at rest). Participants who reported dyspnea as their current limiting symptom for Class II to IV physical activities were compared with participants in Class I.

The diagnoses of chronic bronchitis and asthma were adjudicated based on typical symptoms (chronic productive cough and wheezes, respectively).[14,15] Smoking status was assessed as never, past, or current smoker. For the purpose of this study, past and current smokers were contrasted with never smokers. The diagnosis of heart failure was based on the direct detection of typical symptoms and signs, according to the criteria proposed by one study.[16]

Anthropometric Measures

Standing stature (SS) was obtained with participants standing barefooted against the wall, their head positioned according to Frankfurt plane (i.e., with the lower margins of the orbital openings and the upper margins of the auditory meatus lying in the same horizontal plane). The OWD, which is an indirect indicator of the severity of kyphosis,[11] was measured in this position.

Knee height was measured with participants lying barefoot in the supine position, with their ankle, knee, and tibia-tarsus joints flexed at 90°. A steel caliper (SECA, Mod. 209, Vogel & Halke, Hamburg, Germany) was used, positioning the measurement bar along the lateral tibia condyle and the lateral malleolus, the fixed transverse component under the heel and the sliding component placed upon the upper face of the thigh. The same observer took repeated measurements until two readings within the nearest centimeter were obtained. Formulas previously developed[17] and validated in this same population[18] were used to derive stature from knee height (knee-height stature (KHS), cm). The difference between SS and KHS (difference stature (DS), cm) was considered to be an indicator of the severity of kyphosis. DS was set equal to 0 when, as a result of the predictive equation, KHS was lower than SS.

Body weight (kg) was measured using a balance scale with the participant wearing lightweight clothing and no shoes. Body mass index (BMI) (kg/m^2) was calculated as weight divided by KHS squared.

Spirometry

Spirometry was performed using a bell spirometer (Biomedin, Padova, Italy), which fulfilled the technical requirements of the American Thoracic Society[19] and was interfaced with a personal computer for real-time analysis of spirograms and calculation of the derived parameters (BAIRES 3.2, Biomedin, Padova, Italy). Examiners and evaluators were blinded to clinical status and anthropometric variables. To be included in the study, participants had to perform at least three flow-volume curves of acceptable technical quality, according to the standards of the American Thoracic Society.

Forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) were expressed as the percentage of predicted values, calculated from equations previously proposed.[20] Because height is included in the predicting equations for these parameters, two sets of reference values were obtained, based on SS and KHS (FVC_{SS}, FVC_{KHS}, $FEV1_{SS}$, $FEV1_{KHS}$). When, as a result of the previously reported formulas,[17] KHS was lower than SS, no correction was applied, so that $FEV1_{KHS}$ and FVC_{KHS} coincided with $FEV1_{SS}$ and FVC_{SS}, respectively.

The presence of an abnormal ventilatory pattern was defined based on FVC, FEV1, and their ratio (FEV1/FVC). Following the criteria for moderate to severe chronic obstructive pulmonary disease previously reported,[21] an obstructive ventilatory pattern was diagnosed when FEV1/FVC was less than 70% and FEV1 was less than 80% of the predicted value. An FEV1/FVC of 70% or greater with FVC less than 80% of predicted value was taken to indicate a restrictive ventilatory pattern. A postbronchodilator test was performed to assess the reversibility of airway obstruction. Unless otherwise specified, data refer to prebronchodilator test.

Analytical Procedures

Statistical analysis was performed using SPSS for Windows 10.1 (SPSS Inc., Chicago, IL). Mean values are expressed as mean ± standard error of the mean. Relative frequencies were compared using the chi-square test. The multivariate risk of a dichotomous outcome was assessed as prevalence odds ratio (POR) ± 95% confidence interval (CI) from logistic regression models, where age, sex, and the presence of kyphosis were entered initially, followed stepwise by other continuous (age and BMI) or dichotomous covariates (sex, smoking history, obstructive spirometric pattern, and diagnosis of chronic bronchitis and asthma). The Hosmer-Lemeshow method was used to assess the goodness of fit of logistic regressions.

Comparisons of continuous variables between kyphotic and nonkyphotic participants were conducted with analysis of variance models, in which age, sex, smoking history, and diagnosis of chronic bronchitis and asthma were entered as covariates. Pre- and postbronchodilation values of FEV1/FVC were compared using the *t* test for paired observations.

Multivariate regression models were used to evaluate whether the severity of ventilatory dysfunction, as assessed using FVC, FEV1, and FVC/FEV1, was associated with the severity of kyphosis, expressed by OWD and DS.

A two-tailed *P*-value of less than .05 was considered statistically significant.

RESULTS

Of the 614 participants examined, 400 performed a spirometric test of technically adequate quality. Thirty-six participants who met the diagnostic criteria for heart failure, 28 who reported a history of kyphoscoliosis at a young age or of thoracic surgery, eight in whom anthropometric data were missing, and five who were diagnosed with Parkinson's disease (which is known to be associated with spine and ventilatory abnormalities[22,23]) were excluded from the analysis. Thus, the final study population included 323 participants, of whom 142 (44.0%) were men. Mean age was 72.2 ± 0.3 (range 65–94). Those who were not included were older (74.7 ± 0.3; $P < .001$) than the 323 participants included in the present study and had a similar proportion of women (60.8% vs 56.0%; $P = .230$).

One hundred thirty participants (40.2%) were diagnosed with thoracic kyphosis. The prevalence of kyphosis increased sharply with age: 36.4% of participants aged 65 to 74, 46.1% of those aged 75 to 84, and 81.8% of those aged 85 and older (χ^2 for linear trend = 8.441, $P = .004$). The principal characteristics of the study population, in the presence or absence of kyphosis, are summarized in Table 1. Kyphotic participants were significantly older than those without kyphosis. Their SS was significantly smaller, whereas their OWD and DS were greater, than of participants without kyphosis. The presence of kyphosis was associated with a higher prevalence of dyspnea (16.3% vs 5.7%, POR = 3.3, 95% CI = 1.5–6.9; $P = .002$), in spite of a similar prevalence of smoking, chronic bronchitis, and asthma (Table 1). Adjustment for age, sex, smoking history, diagnosis of chronic bronchitis, and asthma in a multivariate logistic regression model only partially reduced the strength of the association between kyphosis and dyspnea, which remained statistically significant (POR = 2.5, 95% CI = 1.1–5.8; $P = .037$).

Spirometric Evaluation

Comparisons of spirometric variables between kyphotic and nonkyphotic participants are shown in Table 2, unadjusted and adjusted for age, sex, smoking history, and diagnosis of chronic bronchitis and asthma. Kyphotic participants had significantly lower FVC, FEV1, and FEV1/FVC. As expected, the differences in adjusted FVC and FEV1 values between kyphotic and nonkyphotic participants were larger (from 6.3% to 7.7% and from 7.5% to

Table 1. Characteristics of the 323 Study Participants, by Presence or Absence of Thoracic Kyphosis

Characteristic	Kyphosis (n = 130)	No Kyphosis (n = 193)	*P*-value
Age, mean ± SEM	73.5 ± 0.5	71.3 ± 0.4	<.001
Male, n (%)	56 (43.1)	87 (44.6)	.792
Standing stature, cm, mean ± SEM	156.5 ± 0.8	159.4 ± 0.7	.005
Knee height derived stature, cm, mean ± SEM	158.2 ± 0.7	159.3 ± 0.6	.255
Standing stature – knee-height-derived stature, cm, mean ± SEM	− 2.5 ± 0.3	− 1.4 ± 0.1	<.001
Occiput-wall distance, cm, mean ± SEM	7.9 ± 0.2	6.1 ± 0.2	<.001
Body weight, kg, mean ± SEM	65.9 ± 1.0	69.2 ± 0.9	.017
Goldman's Specific Activity scale, n (%)*			
Class I	108 (83.7)	182 (94.3)	
Class II	15 (11.6)	9 (4.7)	.002
Class III–IV	6 (4.7)	2 (1.0)	
Current or previous smoking	58 (44.6)	92 (47.7)	.590
Chronic bronchitis†	20 (15.7)	23 (12.2)	.373
Asthma‡	5 (4.0)	5 (2.7)	.535

* Data on Goldman's classification were missing in one participant with kyphosis.
† Data necessary for the clinical diagnosis of chronic bronchitis were missing in three participants with and five without kyphosis.
‡ Data necessary for the clinical diagnosis of asthma were missing in four participants with and eight without kyphosis.
SEM = standard error of the mean.

Table 2. Spirometric Variables, by Presence or Absence of Thoracic Kyphosis

	Unadjusted			Adjusted*		
	Kyphosis (n = 130)	No Kyphosis (n = 193)		Kyphosis (n = 126)	No Kyphosis (n = 185)	
Variable	Mean ± SEM		*P*-value	Mean ± SEM		*P*-value
FVC_{SS} (% of predicted)	91.1 ± 1.7	97.8 ± 1.2	.001	82.8 ± 3.0	89.1 ± 3.0	.002
FVC_{KHS} (% of predicted)	87.5 ± 1.7	95.8 ± 1.2	<.001	79.7 ± 3.0	87.4 ± 3.0	<.001
$FEV1_{SS}$ (% of predicted)	88.8 ± 2.0	96.6 ± 1.4	.001	70.2 ± 3.3	77.7 ± 3.3	.001
$FEV1_{KHS}$ (% of predicted)	85.4 ± 1.9	94.6 ± 1.3	<.001	67.3 ± 3.3	76.2 ± 3.2	<.001
FEV1/FVC (%)	69.2 ± 1.0	71.2 ± 0.6	.017	59.7 ± 1.4	61.6 ± 1.4	.052

* Least square means, adjusted for age, sex, smoking history, and diagnosis of chronic bronchitis and asthma.
SEM = standard error of the mean; FVC = forced vital capacity; SS = standing stature; KHS = knee-height-derived stature; FEV1 = forced expiratory volume in 1 second.

8.9%, respectively) when KHS was used instead of SS to calculate the predictive values. For this reason, the subsequent analyses were based on KHS-derived spirometric parameters.

In multivariate regression models, the severity of kyphosis, as independently assessed using OWD and DS, predicted the severity of ventilatory dysfunction, as expressed using spirometric parameters (Table 3). The magnitude of the decrease in FVC_{KHS} (1.12% and 1.62% per each cm increase in OWD and decrease in DS) was approximately proportional to the magnitude of the decrease in $FEV1_{KHS}$ (1.39% and 1.30% per each cm decrease in OWD and increase in DS). Therefore, the ratio of these two variables (FEV1/FVC) was independent of OWD or DS.

Of the 193 nonkyphotic participants, 149 (77.2%) had a spirometric pattern of normal ventilatory function, whereas 23 (11.9%) and 21 (10.9%) showed an obstructive and restrictive ventilatory pattern, using the KHS-derived spirometric variables. In the presence of kyphosis, the corresponding figures were 73 (56.2%), 35 (26.9%), and 22 (16.9%), respectively ($\chi^2 = 16.878$, $P < .001$). The association between kyphosis and each ventilatory pattern was assessed in two separate multivariate logistic regression models by contrasting participants with an obstructive pattern, or those with a restrictive pattern, with those with a normal ventilatory pattern. Because of missing values in some covariates (diagnosis of chronic bronchitis and asthma), the numbers of participants included in the two final regression models were 56, 40, and 215, respectively. Kyphotic participants had more than three times the risk of an obstructive pattern, independent of age, sex, smoking history, and diagnosis of chronic bronchitis or asthma (Table 4). In a similar logistic regression model, which included age, sex, and KHS-derived BMI, thoracic kyphosis was also associated with twice the risk of a restrictive pattern (Table 4).

In the presence of an obstructed ventilatory pattern, FEV1/FVC did not change significantly after bronchodilation in the 23 nonkyphotic participants (1.6% absolute change; $P = .135$) and the 34 kyphotic participants (-1.1% absolute change; $P = .309$).

DISCUSSION

As this and other studies show, thoracic kyphosis is observed with increasing frequency in late life. In a sample of healthy pre- and postmenopausal women, the prevalence of kyphosis was 35%, and an association with aging was seen only in postmenopausal participants.[24] Vertebral deformities and fractures, a frequently unrecognized cause of kyphosis,[25] were found in 36% and 46% of men and women aged 80 and older.[26] In addition to vertebral fractures, other age-related changes of the

Table 3. Prediction of the Severity of Ventilatory Dysfunction Based on Measures of the Severity of Kyphosis, from Age- and Sex-Adjusted Multivariate Regression Models of 323 Older Persons

Measures of Severity of Kyphosis	Beta Coefficient	Standard Error (Beta Coefficient)	*P*-value
FVC_{KHS} (% of predicted)			
Occiput-wall distance, cm	−1.15	0.38	.003
Difference SS-KHS, cm	1.64	0.39	<.001
$FEV1_{KHS}$ (% of predicted)			
Occiput-wall distance, cm	−1.39	0.45	.002
Difference SS-KHS, cm	1.34	0.46	.004
FEV1/FVC (%)			
Occiput-wall distance, cm	−0.23	0.28	.266
Difference SS-KHS, cm	−0.26	0.29	.218

FVC = forced vital capacity; KHS = knee height derived stature; SS = standing stature; FEV1 = forced expiratory volume in 1 second.

Table 4. Logistic Regression Models for the Risk of an Obstructive or a Restrictive Ventilatory Pattern, Defined Based on Spirometric Parameters Derived from Knee-Height Stature

	Obstructive (n = 56) vs Normal Pattern (n = 215)		Restrictive (n = 40) vs Normal Pattern (n = 215)	
Parameter	POR (95% CI)	*P*-value	POR (95% CI)	*P*-value
Age	1.0 (0.9–1.1)	.995	1.0 (0.1–1.1)	.461
Female	0.7 (0.3–1.3)	.221	2.1 (1.0–4.5)	.051
Kyphosis	3.3 (1.7–6.5)	<.001	2.3 (1.1–4.8)	.021
Chronic bronchitis	3.7 (1.6–8.5)	.002	—	—
Asthma	11.2 (1.2–67.6)	.008	—	—

Note: In a stepwise procedure to select variables, smoking history and body mass index were not included in the final models for the prediction of obstructive and restrictive ventilatory pattern, respectively.
POR = prevalence odds ratio; CI = confidence interval.

musculoskeletal system and of the spine may be responsible for kyphosis.[4,5]

A spectrum of breathing abnormalities has been reported in young and middle-aged individuals with idiopathic and paralytic kyphoscoliosis, including altered lung mechanics and blood gases, increased work of ventilation, and hypoventilation, particularly during sleep.[27,28] Yet, in spite of the high prevalence of spine deformities in the expanding segment of the aging population, the ventilatory consequences of thoracic kyphosis in older persons have been poorly investigated. Previous research, conducted only in limited clinical series, showed a decline in vital capacity proportional to the severity of vertebral changes.[10,11] The present epidemiological study demonstrates that kyphosis is associated with ventilatory dysfunction in community-dwelling older persons, to the authors' knowledge, an observation never previously reported. Also, after adjusting for age, kyphotic participants had more than twice the risk of dyspnea as nonkyphotic participants, which associated conditions such as smoking, chronic bronchitis, or asthma could not explain. The spirometric examination confirmed that lung function was significantly impaired in kyphotic participants, independent of coexisting comorbidities and proportional to the severity of kyphosis, as assessed using indirect measures such as OWD and DS.

Thus, thoracic kyphosis should be considered to be a risk factor for reduced ventilatory function and dyspnea in the elderly, an observation with remarkable clinical implications. Kyphosis should be included in the differential diagnosis of dyspnea in older persons, a challenge that clinicians must often confront. This might even imply that the frequency of heart failure attributed to left ventricular diastolic dysfunction,[29] which is a diagnosis of exclusion when other plausible causes of dyspnea in the elderly have been excluded, has been previously overestimated. This speculation must be confirmed in further investigations. To reduce the risk of confounding from cardiac causes of dyspnea, participants with a standardized diagnosis of heart failure were excluded from the present study. As previously reported,[30] the chances of obtaining a technically satisfactory spirometric assessment decrease with worsening physical and cognitive status at an advanced age. Participants who could not be included in the present study, mainly because of poor quality of their spirometric test, were older than those who were assessed. Therefore, the findings probably underestimate the true extent of the association between kyphosis and ventilatory dysfunction in the elderly.

Although participants in this study probably represent milder cases of kyphosis, the findings also contribute to explaining the excess mortality from pulmonary causes (hazard ratio = 2.6) reported in women with vertebral fractures and severe kyphosis.[9] Combined, the previously mentioned study[19] and the current results add a further, compelling indication to the prevention and treatment of osteoporosis, the condition primarily responsible for spine deformities in old age. Because other modifiable factors, such as reduced muscle tone, contribute to kyphosis, physical exercise and other interventions might be proposed to reduce hyperkyphotic posture. Yoga has been shown to correct posture and to improve short-term physical functioning in older kyphotic women,[31] but its effects on pulmonary function are unknown.

The abnormality in ventilatory pattern more commonly seen in young individuals with idiopathic kyphoscoliosis is of a restrictive pattern,[32] although an obstructive pattern has been also reported, mainly caused by small-airway obstruction.[33,34] Previous studies in older persons with spine abnormalities, such as a small clinical series of women with osteoporotic vertebral fractures,[10] mainly observed a restrictive pattern. In agreement with a restrictive pathophysiology, rib mobility was lower in a sample of 15 kyphotic women with osteoporosis than in 15 nonkyphotic women.[35] The current community-based study confirmed an association between kyphosis and a restrictive ventilatory pattern but also showed that the more common ventilatory abnormality observed in kyphotic participants was of an obstructive pattern. Kyphosis increased the risk of airway obstruction by more than three times, independent of other conditions that lead to this abnormality, such as chronic bronchitis and asthma. Although other studies are needed to better understand the pathophysiology of ventilatory abnormalities in kyphotic older persons, it is hypothesized that distortion of the large airways, which are forced to follow the abnormal curvature of the kyphotic spine, represent the leading mechanism for obstruction. A similar pathophysiology has

been observed in patients with Parkinson's disease, in whom cervical arthritis and limitations of passive movement of the neck have been reported to be associated with central airway obstruction, although a peripheral obstructive component was also detected.[22]

Other findings of the present study should be further discussed. Kyphosis causes a significant underestimation of a subject's true stature when the conventional standing measure is taken. As a consequence, calculated reference values for spirometric variables can be substantially underestimated, and reduced spirometric parameters can be falsely interpreted as normal. In this study, when reference values were calculated based on KHS, the ventilatory abnormalities associated with kyphosis were much more evident than with the use of SS-derived parameters. Only 56% of the kyphotic participants were classified as normal based on the KHS-derived spirometric parameters, compared with 62% with the SS-derived parameters. The corresponding proportions of nonkyphotic participants classified as normal were 77% with the KHS parameters, versus 82% with the SS-derived parameters. Therefore, these data confirm what other authors have suggested, that an age-independent substitute for standing height should be used to correctly assess predicted values of lung volumes in older persons, especially in the presence of osteoporosis or spine deformities.[36]

Some limitations of this study must be considered. First, the diagnosis of kyphosis and assessment of its severity were based only on a qualitative clinical evaluation and on anthropometric measures. More accurate estimates of the severity of kyphosis can be obtained by measuring Cobb's angle from radiological spine imaging in the lateral projection.[10] Hence, the reliability of this evaluation might be questioned, but the significant differences in OWD and DS between kyphotic and nonkyphotic participants support the face validity of this assessment, which was similar to that used by other investigators.[37] Second, the presence of vertebral fractures, as opposed to alterations of muscular and other soft tissue components, could not be ascertained as a cause of kyphosis and ventilatory dysfunction. It should also be acknowledged that bell spirometry is poorly specific for a diagnosis of restrictive ventilatory pattern, compared with plethismography.[37] Therefore, it is possible that these findings overestimate the frequency of a restrictive ventilatory pattern. Finally, these findings are limited to a small, rural community and do not represent a wide, national population.

In conclusion, this study provides evidence that thoracic kyphosis is a frequent cause of dyspnea and ventilatory dysfunction in older persons. These findings are consistent with the increased mortality from pulmonary disease observed in older women with spine deformities. Accordingly, prevention of kyphosis might reduce the burden of respiratory morbidity and mortality at an advanced age.

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